Department of Electronics and Communication Engineering

PRACTICAL RECORD BOOK

21EC44

Principles of Communication Systems Lab

Name: ………………………………………………………………

Semester: ……………………................... Div: ....

USN: ………………………………………………………………...

DEPARTMENT VISION

The Electronics and Communication Engineering department shall impart quality technical education and entrepreneurship skills to develop creative individuals to face changing global scenario.

DEPARTMENT MISSION

To augment the national talent pool, with Electronics and Communication Engineers having all-encompassing technical knowledge, principled practices and nationalistic outlook.

Course Outcome (COs)

At the end of the course, the student will be able to	Bloom's Level
1. **Distinguish** between analog and digital communication system and **analyze** effect of noise in communication systems	L2
2. **Analyze** suitable digital coding of Analog waveforms and **design** noiseless communication system	L3
3. **Understand** suitable encoding technique for communication systems and **develop** an efficient modulation technique	L4

Program Outcome of this course (POs)

Sl.no.		PO No.
1.	**Engineering Knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.	**1**
2.	**Problem Analysis:** Identify, formulate, research literature and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.	**2**
3.	**Design/ Development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.	**3**
4.	**Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of information to provide valid conclusions.	**4**
5.	**Modern Tool Usage:** Create, select and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.	**5**
5.	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.	**8**
6.	**Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams and in multidisciplinary settings.	**9**
7.	**Life-long Learning:** Recognize the need for and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological change.	**12**

Karnatak Law Society's
Gogte Institute of Technology, Udyambag, Belagavi
Department of Electronics and Communication Engineering

LABORATORY CERTIFICATE

This is to certify that ……………………………………bearing USN... has satisfactorily completed the course of experiments in 21EC44 Principles of Communication Systems lab prescribed by the department of Electronics and communication Engineering for the fourth semester of UG program during the year 2022-23.

Signature of Faculty-In-Charge　　　　　　　　Signature of Head of the Department

Date:

Karnatak Law Society's

Gogte Institute of Technology, Udyambag, Belagavi

Department of Electronics and Communication Engineering

Principles of Communication Systems Laboratory (21EC44) IV semester

INDEX SHEET

Expt. No.	**Date**	**Title**	**CO**	**PO**	**Marks** (out of 15)	**Sign**
1		Spectrum Analysis of Continuous wave	1	1,2,3,5,9,10		
2		Sampling Process	1	1,2,3,5, 9,10		
3		Pulse Amplitude Modulation	1	1,2,3,9,10		
4		Pulse Width Modulation	1,2	1,2,3, 9,10		
5		Delta Modulation	1,2	1,2,3, 9,10		
6		Adaptive Delta Modulation	2,3	1,2,3,5, 9,10		
7		PSD of line codes	2,3	1,2,3,5, 9,10		
8		Digital Modulation Techniques	2	1,2,3, 9,10		
9		Spread Spectrum Modulation	2	1,2,3, 9,10		
10		Generation of PN Sequence	2,3	1,2,3,5, 9,10		
				AVERAGE MARKS		

CIE Marks Distribution

S.No	Details	**Max Marks**	**Marks Obtained**	**Sign**
1	Conduction & Journal	**15**		
2	Lab test	**25**		
	Total Marks	**40**		

INSTRUCTIONS TO THE STUDENTS

1. The lab experiments are divided into PART A (Software) and PART B (Hardware)
2. Hardware experiments are performed in Room No.AT-18 and Software experiments are performed in Room No.AF-27 and Room No. AS-29
3. Students need to perform hardware experiments in groups of 2 per table (teams formed based on USNs) and software experiments individually.
4. During hardware lab sessions, team leader will collect components and return it to lab assistant after completion of the lab session.
5. If any equipment/components found in not working condition, students need to bring it to the notice of concerned staff / lab assistant.
6. Students have to bring the lab manual cum observation book to every lab session.
7. Students need to read through the lab experiment to familiarize themselves with the components and algorithms.
8. Upon successful completion of each experiment, students will be evaluated for 10 Marks.
9. If the experiment is not completed in the stipulated time, the pending work has to be carried out in the leisure hours or extended hours and it should be signed by the concerned staff in-charge.
10. Students should submit the completed record book according to the deadlines set up by the staff- in-charge.
11. Disciplinary action will be taken against the students if he/she is found in violating the lab guidelines/ instructions given by the staff- in-charge or lab assistant.
12. Lab CIE distribution is as follows:

Conduction and journal	Calculations, results, graph, conclusion and Outcome	Viva voce	Lab Test	Total
05	05	5	25	40

13. Lab test: (Batch wise with 15 students/batch)

    i. Conducting the experiment and writing report: 5 marks
    ii. Calculations, results, graph and conclusion: 10 marks
    iii. Viva voce: 10 marks

14. Eligibility for SEE: 40% and above (16 marks and above) in lab component and 40% and above (24 marks and above) in theory component.

I hereby declare that, I have read and understood all the communication lab instructions and I shall strictly abide by it.

Student Name	
USN	
Signature with date	

Experiment No: 1 **Date:**

Title: Spectrum Analysis of Continuous Wave.

Objective: To generate a continuous time (CT) signal and analyze its spectrum.

Algorithm:

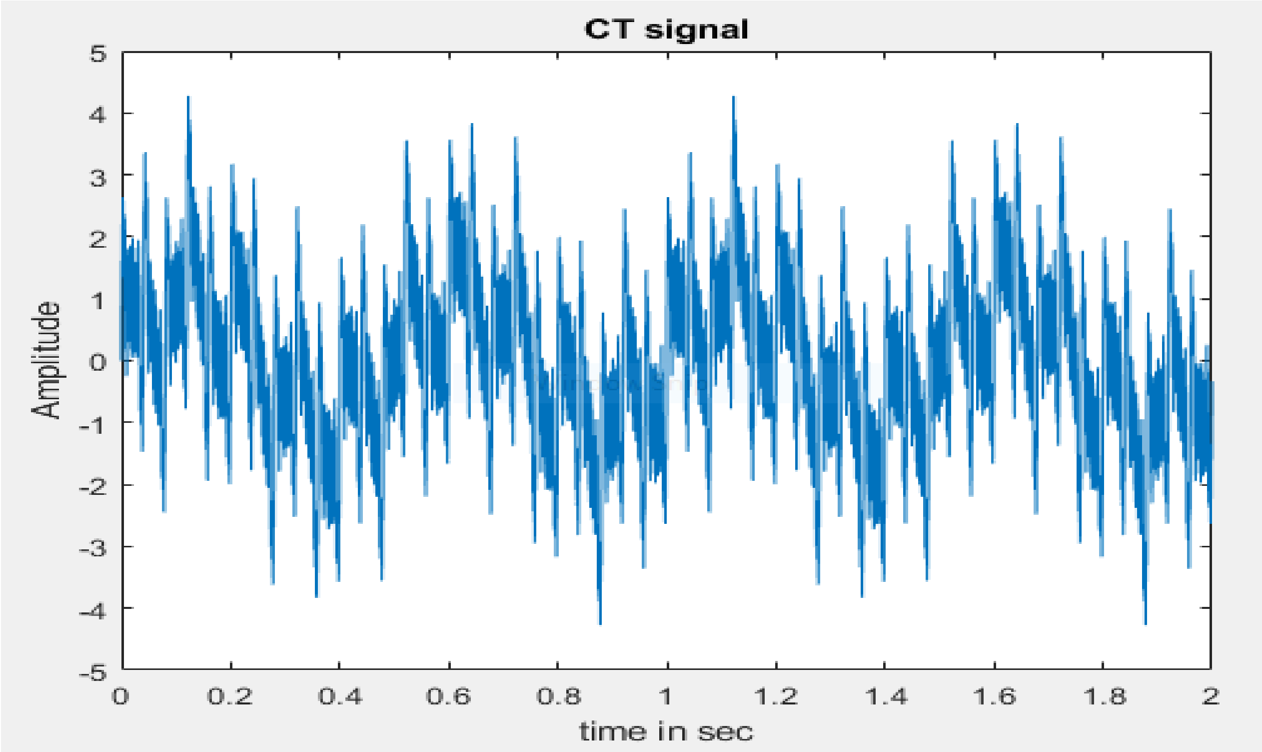
1. Assume a large sampling rate "fsct" to simulate continuous time signal.
2. Choose different frequency components in the signal f1, f2, ….
3. Set the duration of the signal t.
4. Generate the discrete time vector n.
5. Generate different frequency sinusoids x1, x2, ….
6. Combine different frequency components with different strengths (perform scaled addition).
7. Apply Fourier transform on the combined signal.
8. Plot the time domain and frequency domain signal.

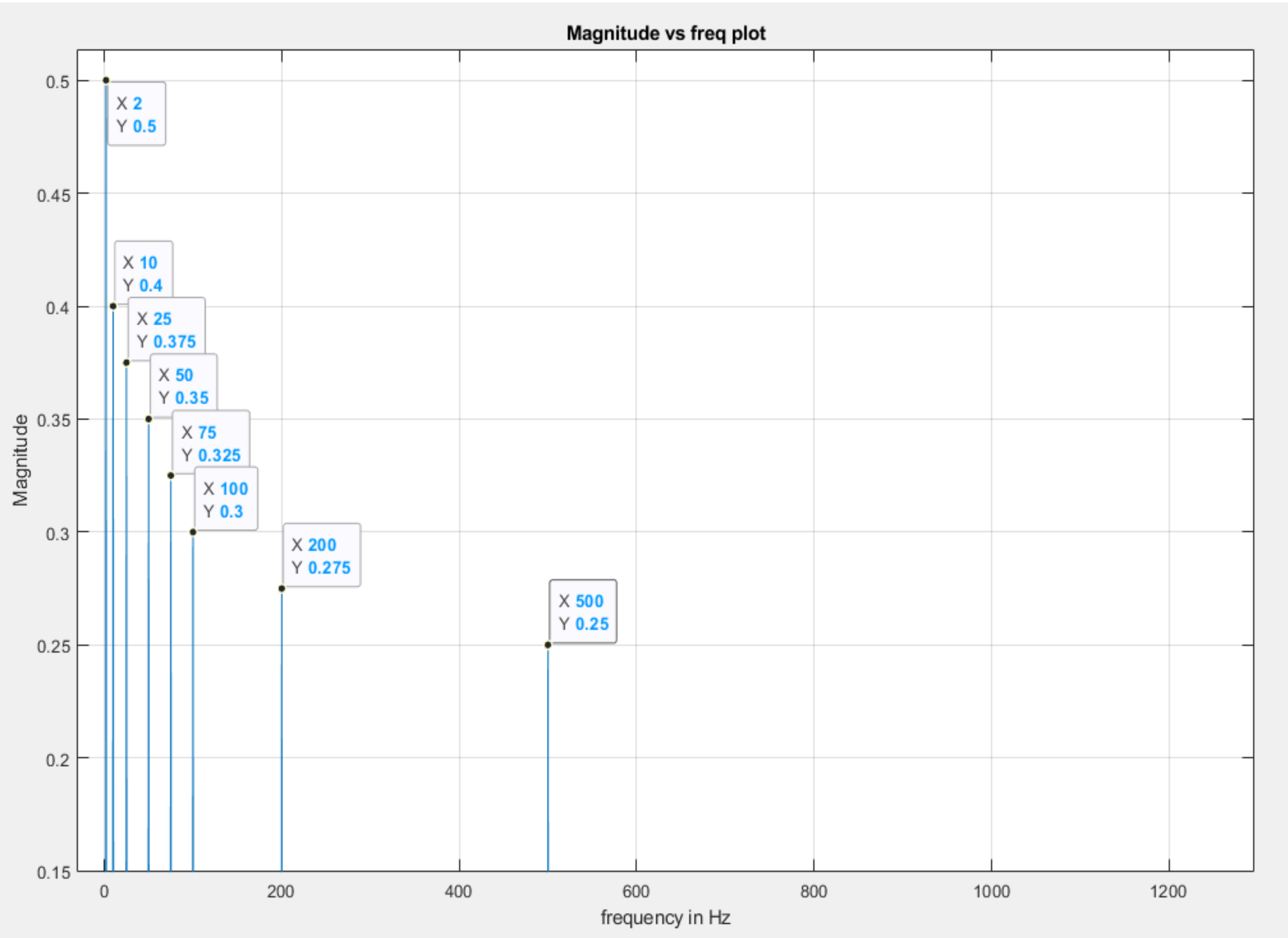
MATLAB Script:

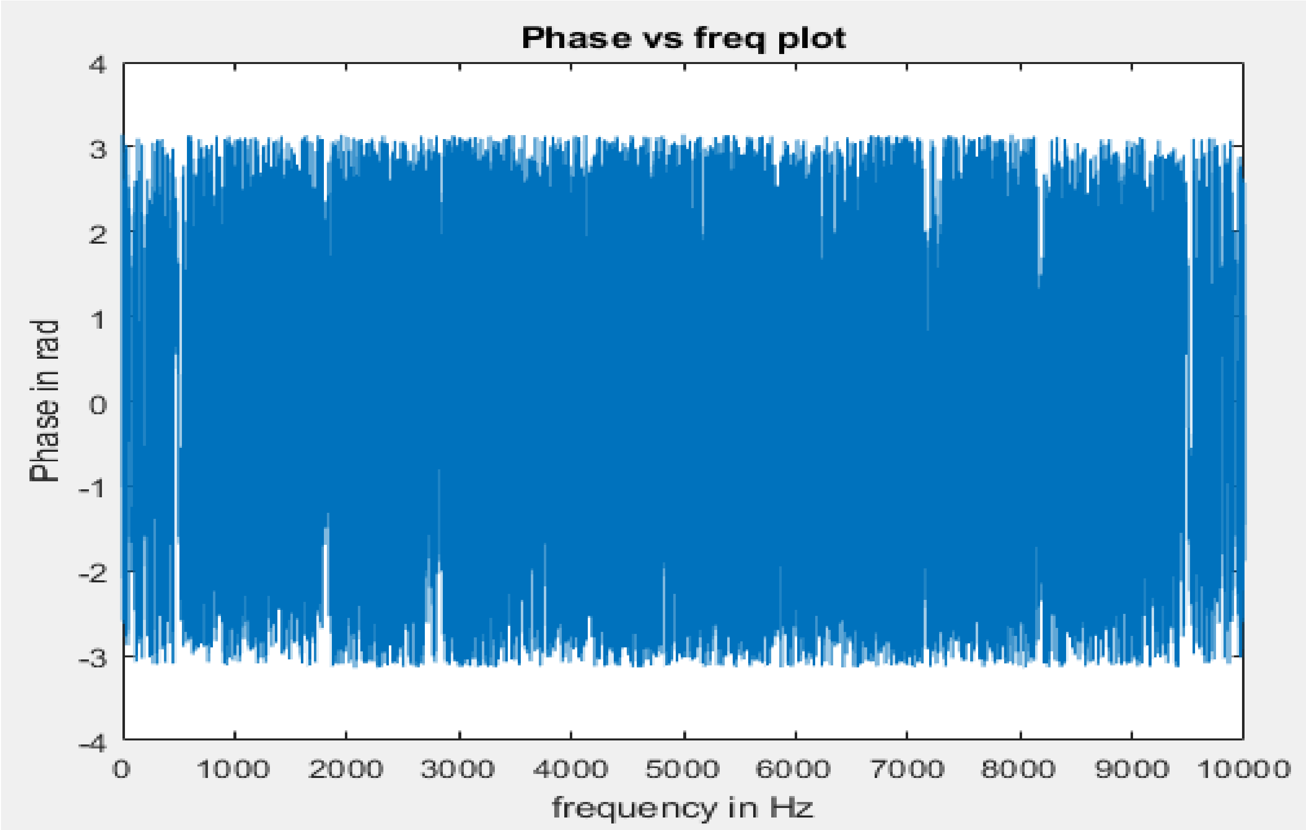
```
clear all;close all;clc;

%Generate CT Signal:
fsct = 10000; % step 1: Taking large sampling rate to simulate
CT signal

% step 2: Signals in real life contains band of frequencies:
% f1 to f8 are 8 different frequency components in Hz
f1 = 2; f2 = 10; f3 = 25;
f4 = 50; f5 = 75; f6 = 100;
f7 = 200; f8 = 500;

t = 2; % step 3: duration of the signal in seconds

n = 0:1:(t*fsct)-1; % step 4: Discrete time index (sample
number)

% step 5: Generating different frequency sinusoids
corresponding to f1 to f8:
x1 = sin(2*pi*(f1/fsct)*n);
x2 = sin(2*pi*(f2/fsct)*n);
x3 = sin(2*pi*(f3/fsct)*n);
x4 = sin(2*pi*(f4/fsct)*n);
x5 = sin(2*pi*(f5/fsct)*n);
x6 = sin(2*pi*(f6/fsct)*n);
x7 = sin(2*pi*(f7/fsct)*n);
x8 = sin(2*pi*(f8/fsct)*n);
```

```
% step 6: Combining the different frequencies to form composite
signal:
xct = x1+(0.8*x2)+(0.75*x3)+(0.7*x4)...
    +(0.65*x5)+(0.6*x6)+(0.55*x7)+(0.5*x8);

% Plotting the time domain signal:
figure(1),plot(n/fsct,xct);
xlabel('time in sec');
ylabel('Amplitude');
title('CT signal');

% step 7: Converting time domain signal to frequency domain:
Nct = length(xct);% Number of points in FFT
Xct = fft(xct, Nct); % Taking Fast Fourier Transform (FFT)

% Frequency index kct:
kct = 0:1:Nct-1;

% Converting integer frequency index kct to frequency in Hz:
fct = kct*fsct/Nct;

% step 8: Plotting the frequency specrum:
figure(2), plot(fct,abs(Xct)/Nct);
grid on;
xlabel('frequency in Hz');
ylabel('Magnitude');
title('Magnitude vs freq plot');

figure(3), plot(fct,angle(Xct));
xlabel('frequency in Hz');
ylabel('Phase in rad');
title('Phase vs freq plot');
```

Output:


CT signal
Amplitude
time in sec


Magnitude vs freq plot
Magnitude
frequency in Hz
X 2
Y 0.5
X 10
Y 0.4
X 25
Y 0.375
X 50
Y 0.35
X 75
Y 0.325
X 100
Y 0.3
X 200
Y 0.275
X 500
Y 0.25



Graphs:

Students are instructed to attach the printout of the waveforms.

Space for MATLAB Script (Open Ended):

Inference:

Evaluation:

Attendance (2)	
Journal (3)	
Conduction (5)	
Viva (5)	
Total (15)	
Signature of faculty-in-charge with date	

Experiment No: 2 **Date:**

Title: Verification of Sampling Theorem.

Objective: To verify sampling theorem and to calculate the aliased frequency component.

Theory:

Analog Frequency:

Analog frequency f is measured in cycles per second (CPS) or Hz.

The range of values an f can take is: $\mathbf{0} \leq \mathbf{f} \leq \infty$.

The angular frequency $\boldsymbol{\Omega}$ is defined as:

$$\boldsymbol{\Omega} = \mathbf{2\pi f}$$

which is measured in $\mathbf{rad\ s^{-1}}$.

The range of values $\boldsymbol{\Omega}$ can take is: $-\infty \leq \boldsymbol{\Omega} \leq \infty$.

Digital Frequency:

Normalized digital frequency is defined as

$$\boldsymbol{\omega} = \frac{\mathbf{2\pi f}}{\mathbf{f_s}} = \frac{\boldsymbol{\Omega}}{\mathbf{f_s}}$$

where, $\mathbf{f_s}$ is sampling rate (sampling frequency).

$\boldsymbol{\omega}$ is measured in rad.

The range of values $\boldsymbol{\omega}$ can take is: $\mathbf{0} \leq \boldsymbol{\omega} \leq \mathbf{2\pi}$ or $-\boldsymbol{\pi} \leq \boldsymbol{\omega} \leq \boldsymbol{\pi}$

Mapping of analog frequency to digital frequency:

Any band limited signal having highest frequency component **fmax** is sampled at the Nyquist sampling rate **fs = 2fmax**, the mapping of analog frequency to digital frequency is as follows:

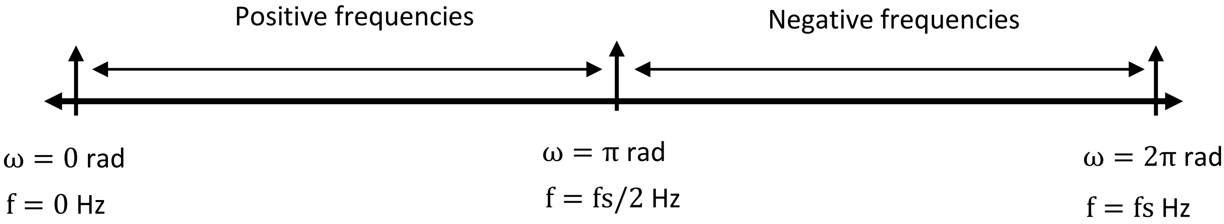
0 Hz is mapped to **0 rad**

fs/2 or fmax Hz is mapped to **π rad**

fs Hz is mapped to **2π rad**

The range 0rad to **π** rad indicate ***positive frequencies***

π rad to **2π** rad indicate ***negative frequencies***.



Algorithm:

1. Assume a large sampling rate "fsct" to simulate continuous time signal.
2. Choose different frequency components in the signal f1, f2, ….
3. Set the duration of the signal t.
4. Generate the discrete time vector n.
5. Generate different frequency sinusoids x1, x2, ….
6. Combine different frequency components with different strengths (perform scaled addition).
7. Apply Fourier transform on the combined signal.
8. Plot the time domain and frequency domain signal.
9. Choose sampling rate fs>=2*fmax and generate the composite signal as mentioned in the steps 2 to 8 (to simulate Nyquist and oversampling conditions)
10. Apply Fourier transform to the composite signal and plot time frequency domain signals.
11. Similarly, generate composite signal with fs<2*fmax (to simulate under-sampling condition).
12. Plot the time and frequency domain signals.

MATLAB Script:

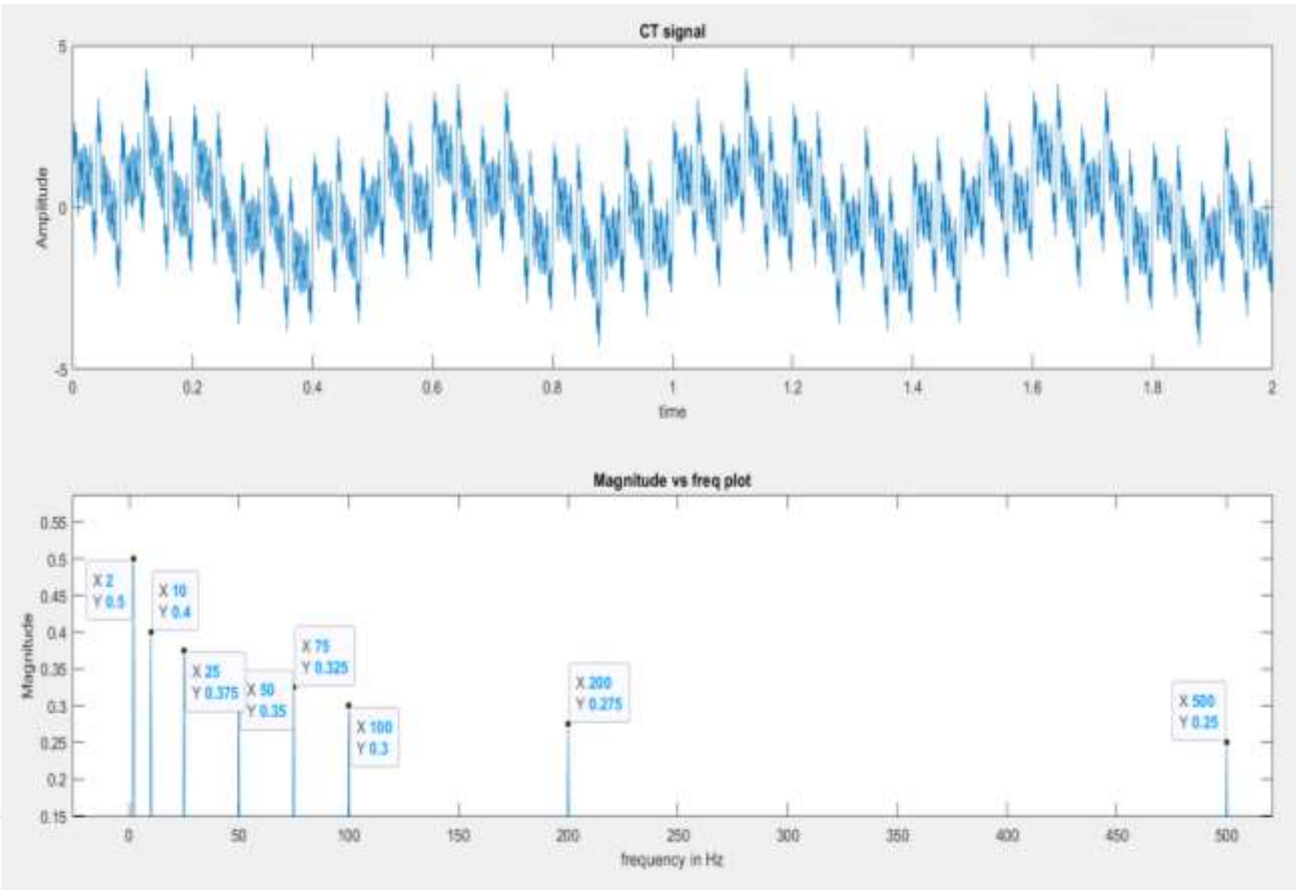
```
clear all;close all;clc;

%Generate CT Signal:
fsct = 10000; % Taking large sampling rate to simulate CT
signal

% Signals in real life contains band of frequencies:
% f1 to f8 are 8 different frequency components in Hz
f1 = 2; f2 = 10; f3 = 25;
f4 = 50; f5 = 75; f6 = 100;
f7 = 200; f8 = 500;

t = 2; % duration of the signal in seconds

n = 0:1:(t*fsct)-1; % Discrete time index (sample number)
```

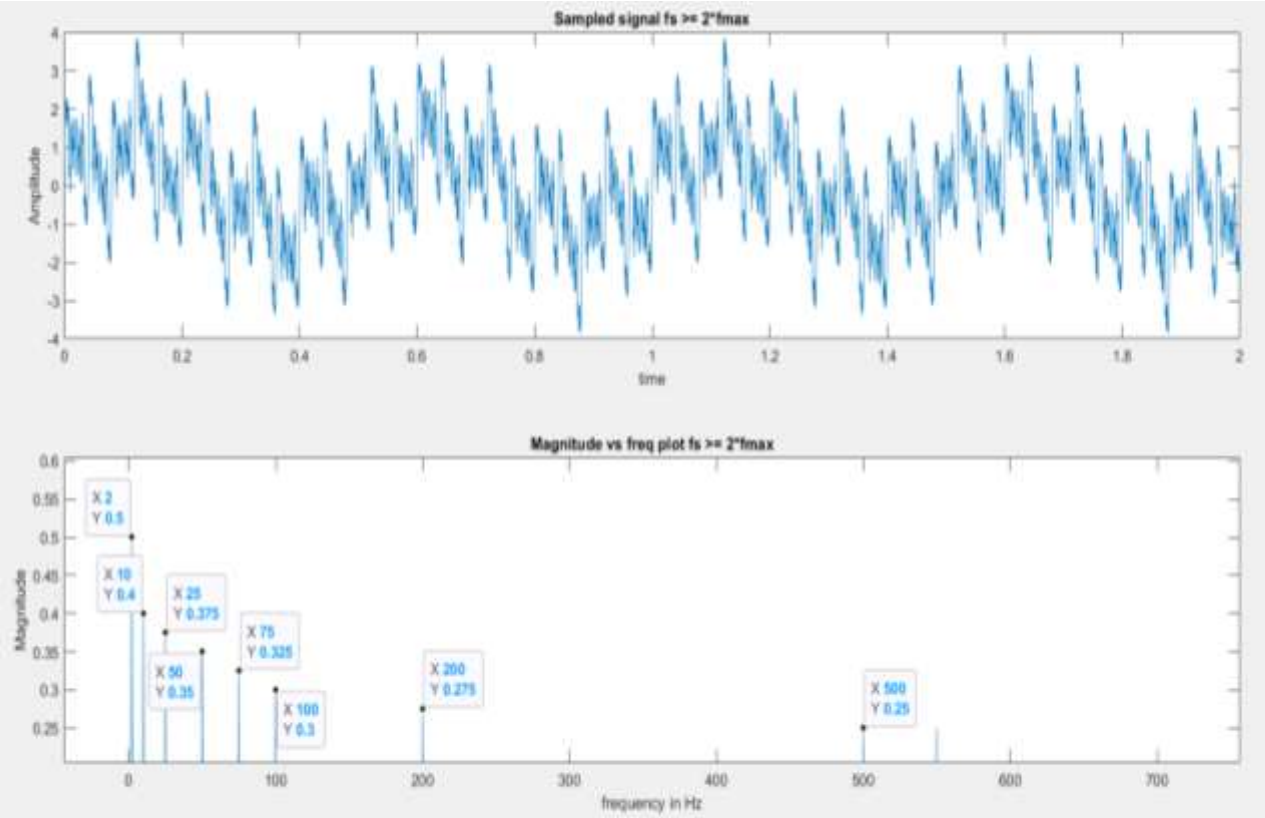
```
% Generating different frequency sinusoids corresponding to f1
to f8:
x1 = sin(2*pi*(f1/fsct)*n);
x2 = sin(2*pi*(f2/fsct)*n);
x3 = sin(2*pi*(f3/fsct)*n);
x4 = sin(2*pi*(f4/fsct)*n);
x5 = sin(2*pi*(f5/fsct)*n);
x6 = sin(2*pi*(f6/fsct)*n);
x7 = sin(2*pi*(f7/fsct)*n);
x8 = sin(2*pi*(f8/fsct)*n);

% Combining the different frequencies to form composite signal:
xct = x1+(0.8*x2)+(0.75*x3)+(0.7*x4)...
    +(0.65*x5)+(0.6*x6)+(0.55*x7)+(0.5*x8);

% Plotting the time domain signal:
figure(1),subplot(2,1,1),plot(n/fsct,xct);
xlabel('time');
ylabel('Amplitude');
title('CT signal');

% Converting time domain signal to frequency domain:
Nct = length(xct);% Number of points in FFT
Xct = fft(xct, Nct); % Taking Fast Fourier Transform (FFT)

% Frequency index kct:
kct = 0:1:Nct-1;

% Converting integer frequency index kct to frequency in Hz:
fct = kct*fsct/Nct;

% Plotting the frequency specrum:
subplot(2,1,2),plot(fct,abs(Xct)/Nct);
xlabel('frequency in Hz');
ylabel('Magnitude');
title('Magnitude vs freq plot');

% Sampled signal-1 with fs >= 2*fmax
fs1 = 1050; % fs >= 2*fmax
n1 = 0:1:(t*fs1)-1; % Discrete time index (sample number)

% Generating different frequency sinusoids corresponding to f1
to f8:
x11 = sin(2*pi*(f1/fs1)*n1);
x12 = sin(2*pi*(f2/fs1)*n1);
x13 = sin(2*pi*(f3/fs1)*n1);
x14 = sin(2*pi*(f4/fs1)*n1);
x15 = sin(2*pi*(f5/fs1)*n1);
```

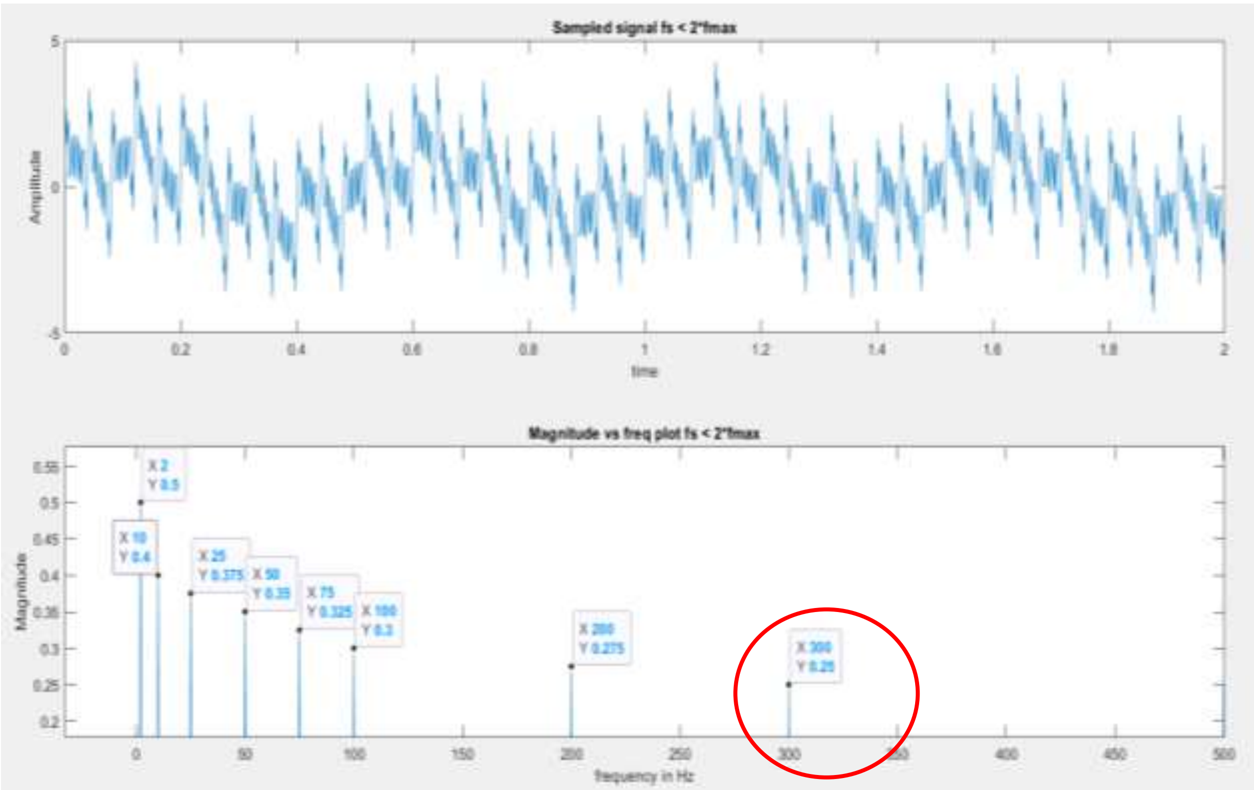
```
x16 = sin(2*pi*(f6/fs1)*n1);
x17 = sin(2*pi*(f7/fs1)*n1);
x18 = sin(2*pi*(f8/fs1)*n1);

% Combining the different frequencies to form composite signal:
xs1 = x11+(0.8*x12)+(0.75*x13)+(0.7*x14)...
    +(0.65*x15)+(0.6*x16)+(0.55*x17)+(0.5*x18);

% Plotting the time domain signal:
figure(2),subplot(2,1,1),plot(n1/fs1,xs1);
xlabel('time');
ylabel('Amplitude');
title('Sampled signal fs >= 2*fmax');

% Converting time domain signal to frequency domain:
Ns1 = length(xs1);% Number of points in FFT
Xs1 = fft(xs1,Ns1);% Taking Fast Fourier Transform (FFT)

% Frequency index kct:
ks1 = 0:Ns1-1;

% Converting integer frequency index kct to frequency in Hz:
f = ks1*fs1/Ns1;

% Plotting the frequency specrum:
subplot(2,1,2),plot(f,abs(Xs1)/Ns1);
xlabel('frequency in Hz');
ylabel('Magnitude');
title('Magnitude vs freq plot fs >= 2*fmax');

% Sampled signal-2 with fs < 2*fmax
fs2 = 800; % fs < 2*fmax

n2 = 0:1:(t*fs2)-1;% Discrete time index (sample number)

% Generating different frequency sinusoids corresponding to f1
to f8:
x21 = sin(2*pi*(f1/fs2)*n2);
x22 = sin(2*pi*(f2/fs2)*n2);
x23 = sin(2*pi*(f3/fs2)*n2);
x24 = sin(2*pi*(f4/fs2)*n2);
x25 = sin(2*pi*(f5/fs2)*n2);
x26 = sin(2*pi*(f6/fs2)*n2);
x27 = sin(2*pi*(f7/fs2)*n2);
x28 = sin(2*pi*(f8/fs2)*n2);

% Combining the different frequencies to form composite signal:
xs2 = x21+(0.8*x22)+(0.75*x23)+(0.7*x24)...
```

```
    +(0.65*x25)+(0.6*x26)+(0.55*x27)+(0.5*x28);

% Plotting the time domain signal:
figure(3),subplot(2,1,1),plot(n2/fs2,xs2);
xlabel('time');
ylabel('Amplitude');
title('Sampled signal fs < 2*fmax');

% Converting time domain signal to frequency domain:
Ns2 = length(xs2);% Number of points in FFT
Xs2 = fft(xs2,Ns2);% Taking Fast Fourier Transform (FFT)

% Frequency index kct:
ks2 = 0:Ns2-1;

% Converting integer frequency index kct to frequency in Hz:
f = ks2*fs2/Ns2;

% Plotting the frequency specrum:
subplot(2,1,2),plot(f,abs(Xs2)/Ns2);
xlabel('frequency in Hz');
ylabel('Magnitude');
title('Magnitude vs freq plot fs < 2*fmax');
```

Output:







Red circled frequency component is aliased.

Calculation of aliased frequency component (fs<2fmax, under-sampling):

Space for MATLAB Script (Open Ended):

Inference:

Evaluation:

Attendance (2)	
Journal (3)	
Conduction (5)	
Viva (5)	
Total (15)	
Signature of faculty-in-charge with date	